U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1771

PREVENTING SOIL BLOWING ON THE SOUTHERN GREAT PLAINS

SOIL BLOWING is often a serious problem in the southern Great Plains. The best preventive and control of soil blowing on cultivated land consists in keeping on the surface materials such as crops, crop residues, or clods, that resist soil movement.

The extent to which a soil is rendered susceptible to blowing while being prepared for a crop depends on the tillage implements used. The merits and demerits of the more important implements are discussed. Land on which winter wheat has been planted may, in spite of precautions, reach a condition that favors soil blowing in the late winter or early spring. Timely preventive cultivation often protects the wheat crop until it can grow enough to form a surface cover. The kind of cultivation to be used depends on the type of soil and its surface condition.

Beans, cowpeas, and similar crops should be grown in strips between strips of sorghum, Sudan grass, or corn. A high stubble left on sorghum land is an aid in preventing soil blowing. A small amount of cultivation is often effective in protecting row-crop land during the winter.

Considerable acreages of land now in cultivation in the southern Plains, especially along the western edge, either are too sandy or have too little rainfall to be depended on for annual crops. Methods should be studied for putting such land back to grass. Other portions of the western sandy lands are capable of raising excellent crops, especially sorghums. However, if they are farmed in large blocks, soil drifting may at critical times spread quickly from one field to another and involve whole neighborhoods. Farmed units should be small and guarded by permanent plantings of grass or browse material. With reasonable-sized holdings there is no reason why soil blowing cannot be controlled, even in years of drought, by the proper management of crop cover and cultivation.

Regrassing by natural or artificial means on the shallower, more sloping, and sandier portions of the Plains is important.

There should be a shelterbelt of trees and shrubbery immediately about every farm home.

On most farms in the western half of the southern Plains it will always be necessary to guard against soil blowing, which may frequently become a serious problem.

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PREVENTING SOIL BLOWING ON THE SOUTHERN GREAT PLAINS

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[Prepared for the Soil Conservation Service]

CONTENTS

THE AREA AND THE PROBLEM

THE SOUTHERN GREAT PLAINS as here discussed extends from northwestern Kansas to central Texas and from the ninety-eighth meridian to the Rocky Mountains. It is devoted in the northern part to winter wheat and the sorghums, along the western edge to some extent to beans, and in the southern part to cotton, wheat, and sorghums.

Soil blowing is often a serious problem from December to May, when the soil is, in many cases, bare and winds are high. This period is often referred to as the "blow season."

Wind movement of soil is dependent on the surface of a field being free of vegetation, crop residues, and clods or other obstructive materials to such an extent that loose, dry soil particles may start moving with the wind. As soon as they start they cut more particles loose, until in a high or characteristically uneven wind a great deal of soil may be in motion in a remarkably short time.

Soil blowing is in all essential features a landslide with the force of the wind substituted for that of gravity. Starting in a very small way at a few points, it may develop to disastrous proportions as wider areas are involved, more soil begins to move, and the cutting into the surface of the fields becomes deeper. In a landslide any cross ledges that tend to diminish the momentum and to lessen the volume of soil in motion tend to make it less destructive. When

[1] Useful suggestions and criticisms have been contributed by C. R. Enlow and H. H. Finnell, of the Soil Conservation Service, and by the following members of the staff of the Division of Dry Land Agriculture: B. F. Barnes, Dalhart, Tex.; A. L. Hallsted, Hays, Kans.; J. B. Kuska, Colby, Kans.; J. S. Cole, C. E. Leighty, and O. R. Mathews, Washington, D. C.

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soil is blowing over the surface the same thing is true. Hence the value of cultivation to form ridges and obstructions, as recommended in the following pages.

The whole art of preventing and controlling soil blowing consists in keeping nonblowing materials on the surface. These may be crops, crop residues, or clods. When crops are absent, the essential feature in preventing soil blowing is the use of implements that lift clods and other nonblowing materials to the surface rather than implements that pulverize or destroy them.

Until recently soil blowing on the southern Plains has not been taken very seriously. Farms in many cases have been isolated. If a man let his farm blow, that was considered his own business. The greater part of the farming was in the eastern edge of the Plains, where rainfall usually was sufficient to make a plant cover of crop or weeds. Periods when conditions were such as to allow the soil to blow were relatively rare.

A vast acreage of land was brought under cultivation during the post-war boom. Much of this was in the drier portion of the Plains, where there is normally more danger of blowing. The increase in acreage was in many instances coincident with a period of ample rainfall, which created a crop cover that prevented blowing. People gave little concern to this potential hazard. Tillage and cropping practices for this new country were not well understood. There was no long period of experience on which to base wise practice. Because of this there was often a poor selection of implements and misuse of them. Practices developed that favored soil blowing. Then suddenly, following a period of more than normal rainfall, came the most extended drought in history. Little cover of either crop or weeds was grown over several years to protect the surface of the soil. This, combined with unwise tillage practices that had developed, caused soil movement on a vast scale.

In some cases the rich surface soil to the depth of several inches has been lost in a relatively short time; great acreages of crop have been ruined, often by soil drifting from neighboring farms; over whole counties and groups of counties conditions have been rendered almost unlivable by frequently recurring dust storms over several months of each succeeding year. Soil movement by the wind has assumed the proportions of a national calamity.

Not all the land involved is in what is normally a high-risk area. The area around Dalhart is in the heart of the blow area, yet past records reveal that it is one of the best and most reliable grain sorghum producing areas in the Great Plains.

Everyone agrees that crop cover is the best method of control. Thirty years of experience have taught men on experiment stations and the more thoughtful farmers much on how to maintain a crop cover. The Soil Conservation Service and the Extension Service are marshaling facts and applying them to large farming regions as rapidly as possible. Under the best methods of crop management, however, the surface of the soil will sometimes be free of vegetation at the time of year when winds are hardest. In such cases the only means of control is by tillage.

Since tillage is dependent on implements, it seems of first importance to consider the implements that may be used and to discuss their merits and shortcomings in relation to soil blowing. In this

discussion it will not be possible to mention all the various implements that may be used, or all the modifications that may be made in those discussed. Neither will it be practicable to give specific directions for methods of controlling blowing applicable in each particular case. From the general principles stated and the specific examples of implement use given, most farmers can probably decide on the correct applications for their farms.

IMPLEMENTS USEFUL IN PREVENTING SOIL BLOWING

Because they have been replaced by more efficient implements, the disk harrow and the spike-tooth harrow are rapidly going out of use. Formerly used quite generally, they were perhaps the worst offenders in pulverizing the soil and putting it in a condition to blow.

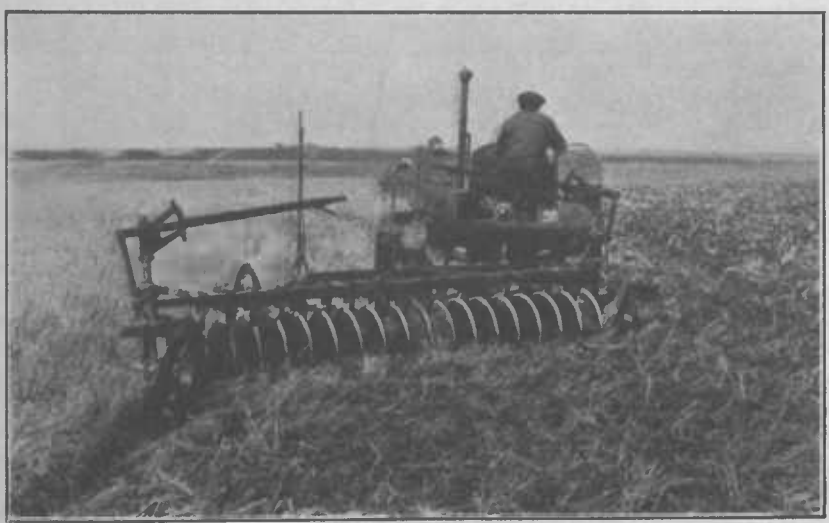

FIGURE 1.—The one-way, an excellent implement for working the heavy stubble left by a combine.

ONE-WAY DISK [2]

There has been a great deal of controversy as to whether the one-way disk should not also be ruled out for semiarid farming. It has many good points and, as often used, certain bad ones. After a winter wheat crop is harvested, the one-way is often the only implement that will dig into the baked surface of hard-land soils, destroy weeds, and open up the soil so that rains will penetrate it. The one-way is also the only implement that will handle the very heavy stubble sometimes left by the combine. The work of a one-way on winter wheat stubble is shown in figure 1. It breaks up the surface soil and destroys weeds without turning under all the straw.

On the other hand, the one-way has frequently been used excessively and at times when it should not have been used. On many

[2] This implement has a variety of trade names, such as disk tiller, one-way disk plow, harrow plow, and wheatland disk. It is commonly called the "one-way."

farms it is the only tillage implement, a fact that has led inevitably to its misuse and to the conviction on the part of some that it should not be used at all. On bare land that is already loose it is inclined to pulverize too much; a great deal of soil blowing can be fairly laid to its use under these conditions. The complaint is made that on some silty soils when the soils are fine and dry, the one-way creates so powdery a surface that rains will not penetrate. However, as stated, it is the only practical implement that will break up heavy land when baked hard, the only implement that can be used in many cases in heavy stubble without clogging, and the best implement to destroy quickly a heavy growth of weeds. By alternating the one-way with other implements, except when there is too much stubble or litter on the ground to permit their use, it can be used safely.

In addition to its other uses, the one-way, with part of the disks removed, may sometimes be successfully employed in arresting soil blowing on hard land difficult to penetrate with other implements. Such cultivation will leave a lumpy and ridged surface which is resistant to soil blowing. (See illustration on title page.)

It seems evident, therefore, that the one-way has a proper place in semiarid agriculture. It has been the means of advancing the efficiency of winter wheat raising more in recent years in this region than anything else except the combine and the tractor.

FIELD OR DUCKFOOT CULTIVATOR

The use of the field or duckfoot cultivator on wheatland has been advocated for years in the northern Plains, but it has come into use very slowly in the southern Plains. Many of the older field cultivators were not constructed so they could be made to penetrate hard soils efficiently, and they are still far behind the one-way in this respect. Their use on hard lands apparently must be confined largely to times when the surface is somewhat loose and there is not a great deal of trash to clog them. Often after harvest the soil can be worked once with the one-way and thereafter with the field cultivator or the rod weeder. Particularly on heavy soils the stiff-shanked field cultivator is often preferred to the spring-shanked type (discussed under spring-tooth harrow).

The field cultivator with duckfoot shovels is a good weed killer and has the advantage of ridging the soil and of bringing clods and trash to the surface. The shovels cutting beneath the surface have very little tendency to pulverize the soil or break down the clods. One of the great draw-backs to the use of the field cultivator has been that the duckfoot shovels have dulled so easily. This may be largely overcome by treating the edges with hardening material.

The several cultivators built to fit some of the tractors are becoming more and more adaptable to various purposes, and it is not improbable that some of them may in time be used in every way that the separate field cultivator can be used; in addition, they may be used to cultivate row crops.

ROTARY ROD WEEDER

The rotary rod weeder (fig. 2) is another implement which after years of limited use in the Plains is being recognized as very efficient in many cases. The rod running 2 inches or more under the surface

and rotating backward tends to throw trash to the surface and does not pulverize surface clods (fig. 3). It is very efficient as a weed destroyer, both after a rain, when a myriad of small weeds are just starting, and when there are scattered big weeds that other imple-

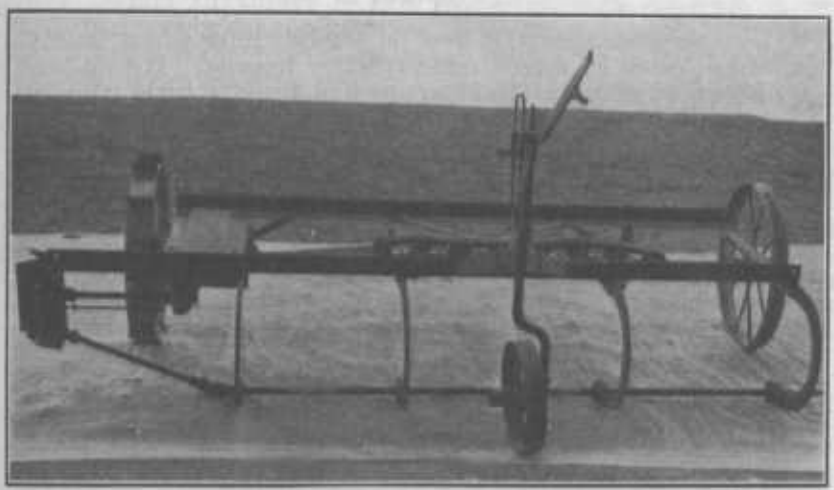

FIGURE 2.—Rotary rod weeder. The rod revolves beneath the surface, with the top moving from front to back. This cuts off and uproots weeds, brings clods and trash to the surface, and breaks up the surface crust without pulverizing it.

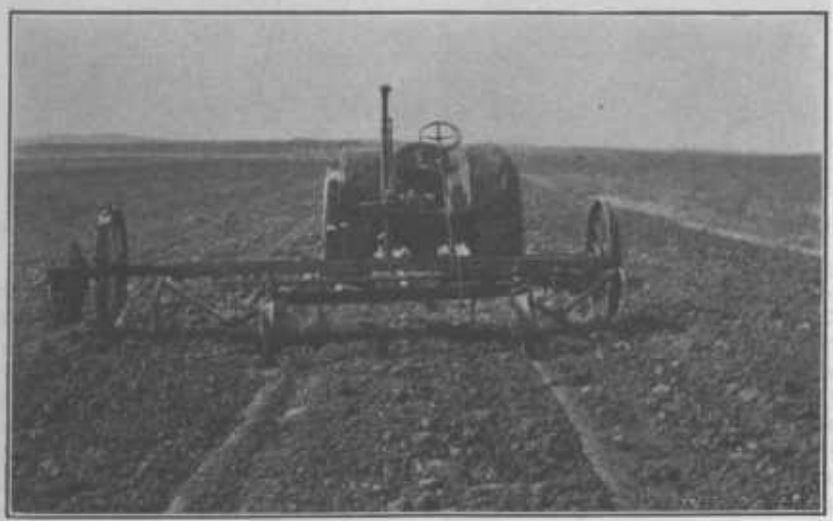

FIGURE 3.—Work of rod weeder, showing how clods are left on the surface.

ments have missed. Its use is confined essentially to times when the surface of the soil is somewhat loose, as it cannot be forced down into a hard soil. On sandy soils that do not pack so hard, the rod weeder as well as the field cultivator may be used to an even greater extent than on hard land. The rod weeder is especially popular for use just previous to seeding, as it creates a level surface, facilitating a uniform depth of seeding. Shallower effective cultivation can be done

with the rod weeder in loose soil than with other implements, so that less moisture in the few inches nearest the surface is sacrificed. This is very important in insuring a stand.

LISTER

The lister is quite generally used on sandy winter wheat land, into which it can often be forced directly after harvest. Heavy land is often one-wayed directly after harvest and listed a little later, after a rain has moistened it. When the stubble is not too heavy and the soil not too dry, stubble can be listed without previous preparation (fig. 4). Lister ridges are pulled down later, with a ridge buster. Any necessary cultivation near seeding time should be shallow and should be done with an implement that does not pulverize the soil as much as the one-way does. A rod weeder is best for the last cultivation before seeding.

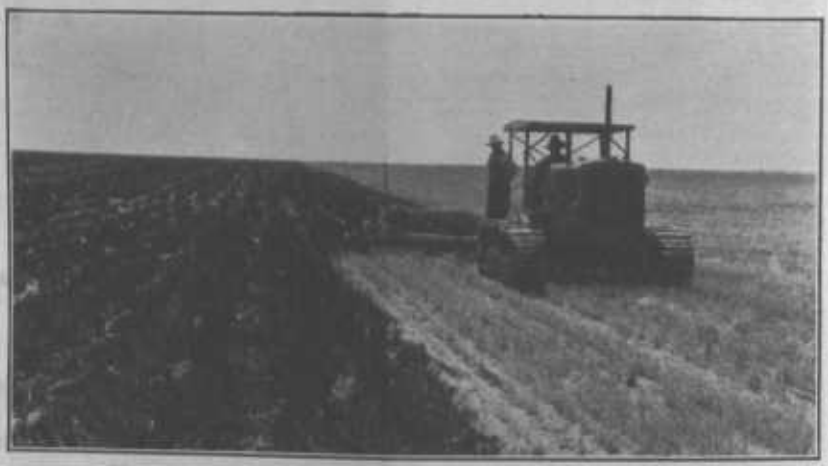

FIGURE 4.—Blank listing after harvest, an operation sometimes used as the first step in the preparation of a seedbed for winter wheat.

Listing after wheat harvest, leveling with a ridge buster, and later working with some other implement has come to be accepted as good practice in the eastern half of the Plains. In the western part of the Wheat Belt during the great drought, there was sometimes insufficient moisture to settle the soil after the ridges were thrown in. Land worked with the lister, year after year, with too little rain to settle it and no straw to bind it, became exceedingly loose and unmanageable. Some farmers continued to use the lister but pulled the ridges in gradually through the summer with the field cultivator or the spring-tooth harrow, rather than pulling them in at one operation with a ridge buster late in the season. Others abandoned the lister in preparing land for wheat, resorting to the one-way and the field cultivator.

The lister is almost universally used for planting row crops in the southern Plains. There are a number of disadvantages in this practice. Under some conditions the crops make a slower start and a poorer yield than surface-planted crops. They are not infrequently

washed under or washed out by torrential rains. Listing, however, is the cheapest and most commonly used method of planting crops on a field basis. It greatly reduces the hazard of injury by blowing. A number of different methods are employed. In some heavy soils it is a distinct advantage to first blank-list, then cultivate in, and plant when nosing out the loose soil in the furrows. In many sandy-soil sections it is the general practice to blank-list as weeds start, and plant later when splitting ridges. Very early listing, splitting ridges, or cultivating in and nosing out is preferred in others, especially where soil blowing is a factor.

In many instances, furrow openers are used on surface planters at experiment stations, because securing a stand is more certain than with a lister. It is possible that with the improvement of farm machinery other modifications of lister planting will result. At present throwing dams in lister furrows to keep water from running off is being tried. In other cases smaller lister moldboards are being

FIGURE 5.—A contour-listed field after a heavy rain.

used with rows of some of the dwarf sorghums planted closer together. Listing on the contour is coming widely into practice (fig. 5).

In some cases the lister is favored for fallowing land, as the cultivation, being more drastic, does not need to be done so often. The method is usually to list early in the season (but not until the weeds are well started), level with a ridge buster, and surface-cultivate with field cultivator or rod weeder.

SPRING-TOOTH HARROW

The spring-tooth harrow has long been advocated but has been little used because it gathers trash so badly. Lately it has become more popular, but it may soon be largely replaced by the spring-shanked field cultivator (fig. 6). This is essentially a spring-tooth harrow on wheels, with the addition of a variety of shovels that can be interchanged as occasion demands. It is easier to transport when not in operation and is less inclined to gather trash than the spring-

tooth harrow. A spring-shanked field cultivator in operation is shown in figure 7.

PACKER

The subsurface packer (fig. 8), which has narrow wheels with wedge-shaped rims, is a favorite implement with some farmers for

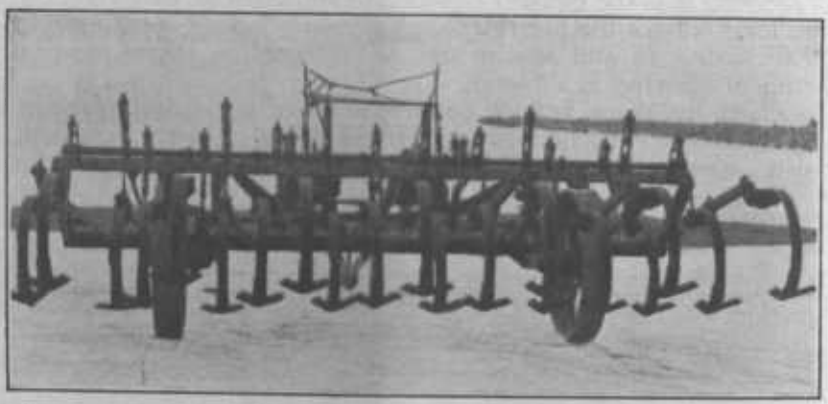

FIGURE 6.—Spring-shanked field cultivator. This implement works well in trash. The V-shaped blades lift clods to the top without pulverizing them.

FIGURE 7.—The spring-shanked field cultivator with duck-foot shovels in operation. It is most excellent for killing weeds and for bringing clods and trash to the surface on summer-fallowed land or land being prepared for wheat.

use on heavy land that breaks up into clods when plowed. The packer breaks down the larger clods and packs the smaller ones together, working fine soil about them, so that air does not circulate so readily and the soil does not dry out so deeply. A better and more compact seedbed is thus formed.

After the one-way has been used on heavy stubble left by a combine, the packer is sometimes used, which presses the straw into the soil in the tracks of the wheels and upends it between them. In this condition the straw tends to obstruct blowing and to delay run-off from heavy rains. Without the use of the packer, the straw some-

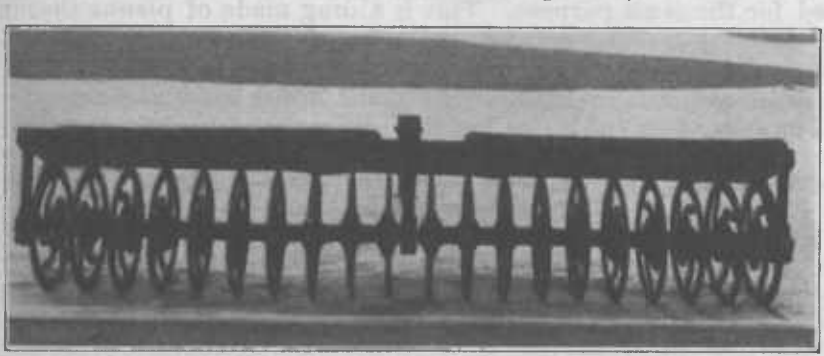

FIGURE 8.—The subsurface packer. Its large wheels with narrow, wedge-shaped rims break down the larger clods and pack the soil beneath without fining the surface.

times forms a dry mat through which it is difficult to force drill disks into the firm soil beneath. Unless the soil is packed, the straw sometimes keeps it from settling, thus causing drying out and dusting whenever there is wind.

FIGURE 9.—A subsurface packer being used to break a surface crust. This operation can be performed on land that has been seeded.

Sometimes on newly planted small grain or sowed feed crops, where the surface has dried and crusted after a rain, soil drifting can be prevented or stopped by running a disk, set straight, over the surface. A subsurface packer may serve the same purpose (fig. 9). These implements crack the crust and make it so uneven that parti-

cles of soil cannot glide over it. They also create depressions into which the blowing particles of soil drop. This method has been employed on fields on which the surface, leveled for irrigation, had become very smooth after a rain.

A home-made device known as a crusting harrow is sometimes used for the same purpose. This is a drag made of planks through which heavy spikes have been driven.

SUGAR-BEET CULTIVATOR

The sugar-beet cultivator has the advantage of having many tools that may be attached to it. These tools are widely adjustable. The beet cultivator may be very useful for general cultivation in irrigated sections or those adjacent. With irrigation shovels attached, it has often been used to throw up ridges to stop drifting. But the beet cultivator is not rugged enough for all uses, and in some cases it gathers trash too badly. Some of the later-type field cultivators are better for general use.

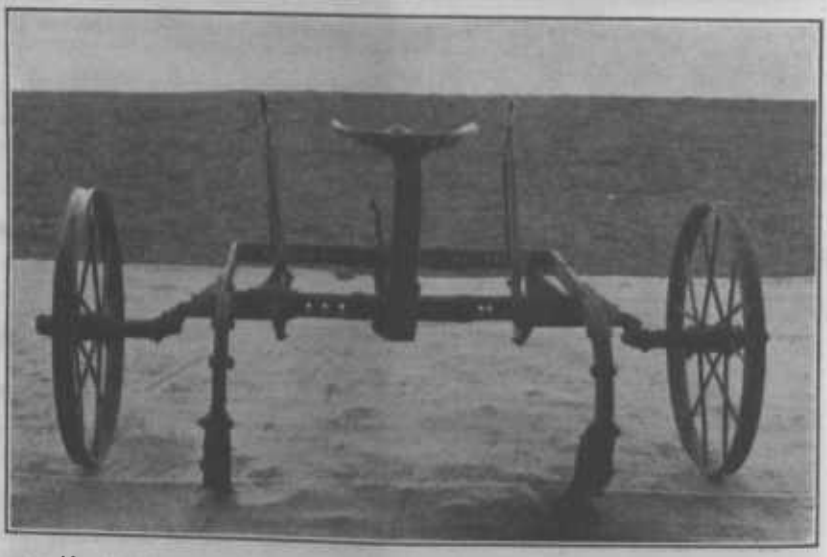

FIGURE 10.—A two-row lister, with the lister bottoms replaced with chisel blades. This implement is particularly efficient in breaking up very hard surfaces or in roughening soils that are too dry to list.

CHISEL

The chisel is essentially a heavy curved cultivator shovel put on a lister in place of a moldboard (fig. 10). Its purpose is to reach deeply beneath the surface and bring up clods that other implements cannot reach. Its action is often more effective in loosening soil deeply than in bringing up clods. It may sometimes be used to advantage to curl up a ribbon of soil when the surface is moist, or to create a cloddy condition on very hard surfaces (fig. 11). The chisel blade attached to a lister shank is usually 2 to 3 inches wide and is often run 12 to 16 inches deep, which requires a great deal of power. A broader blade run at a shallower depth is often more efficient. The draft is so much lighter that several listers so

equipped can be pulled by a tractor and the ground be covered much more rapidly than it could be with the deeper cultivation. Cultivation beyond the ordinary depths of plowing has not been effective in increasing yields.

ROAD SCARIFIER

A road scarifier may sometimes be used to advantage along the edges of hard, smooth roads from which blowing starts. It would be effective in hard fields, though perhaps somewhat expensive to operate.

FIGURE 11.—A two-row lister fitted with chisel blades in place of lister bottoms being used to roughen the hard ditch bottom along a roadway.

OTHER IMPLEMENTS OR DEVICES

A very efficient harrow or rake has been made from a 2-inch steel pipe to which are welded teeth made of ¾-inch steel rods 12 to 15 inches long and spaced about 8 inches apart (fig. 12). The 2-inch pipe is 20 to 30 feet long and requires trussing to keep it from bending. This is a home-made device originating at Big Spring, Tex., and so far as known is not on the market. It is drawn angling across the lister ridges when they have become smooth. It accomplishes very efficient work with very little power. It is probable that it can also be used to roughen ridges made by the furrow drill which have become smooth and hard from beating rains or heavy snows. It might sometimes better be made in sections rather than in one piece, as shown in the illustration.

A furrow drill of either the disk or the shovel type is often found to be efficient in ridging land against blowing, even when not used in planting. It has not proved as efficient against blowing where used for planting wheat as it had been hoped it would be. This is because wheat planted in the wider rows in furrows does not cover the surface so quickly as when planted with an ordinary drill. On

the other hand, when the surface is dry a stand is sometimes obtained which could not be obtained otherwise.

The ordinary lister disk cultivator with the disks removed and only the shovels attached is often useful for running occasional furrows through a field to prevent blowing. While most farmers have such cultivators, they have rarely made use of them in this way.

There are many implements that may be employed to stop soil blowing, and the experieneed man knows the opportune time to make use of them. A man with a farm not too large to be manageable can stop soil drifting under most conditions. Little soil movement has taken place in recent years at the experiment stations on the Plains, because timely control measures have been taken.

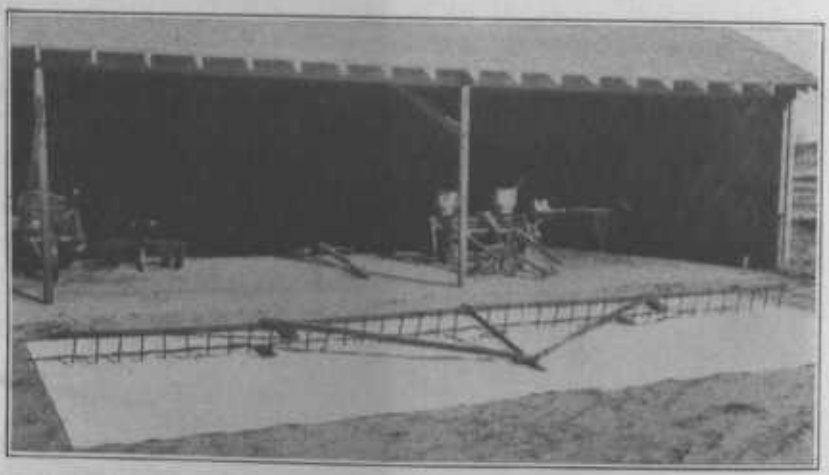

FIGURE 12.—Home-made rake used for breaking the crust on lister ridges. It is used chiefly on sandy soils that crust badly after rains.

CULTIVATION FOR WINTER WHEAT

It may be well to follow a winter wheat crop through the season and consider the possibilities of utilizing cultivation to minimize soil blowing. The cultivations indicated for different parts of the season are discussed separately.

PREPARING THE SOIL FOR PLANTING

This section deals particularly with the preparation of wheatland for the following crop of wheat. A few general principles that apply may be mentioned. Deep cultivations, if performed, should be done early in the season. Cultivation during the rest of the season, and especially near seeding time, should be shallow and of a type that will pack the soil below the immediate surface. This prevents it from drying deeply and provides firm soil for a seedbed. Cultivation at all times should conform to the principles of keeping the surface in condition to absorb rains and keeping on the surface materials that resist soil blowing. These principles are illustrated in the following cases which are representative of conditions likely to occur.

Case 1.—In the summer of 1936 in many sections there was no rain through July and August, so that weeds, except for scattered Russian-thistles, did not start. The weeds that started were pastured off by cattle, and the fields re-

mained clean. The soil the previous season had been worked 3 inches or more by the one-way. Few rains had occurred, so it was still loose as deep as it had been worked. Many farmers had only the one-way with which to cultivate. When worked with this, the soil become a mass of dust to a depth of several inches. If drought continued and no heavy fall of rain occurred, it would blow away. If not worked, many felt that the smooth surface covered with only light stubble would allow great run-off. But most operators decided not to work it. Repeated light rains occurred in September. The land was lightly one-wayed to kill volunteer wheat and was then planted. The land was too hard to work deeply with a lister and too loose to work with a one-way. These were the only two implements available. The safest practice was not to work it until rains occurred and weeds started. If a field cultivator had been available, perhaps the best practice would have been to loosen and roughen the surface with that, and later, after rains occurred, to rod-weed it to kill volunteer plant growth if necessary.

Case 2.—The wheat crop was light despite heavy packing rains in May. The soil after harvest was hard, with a thick growth of small weeds. The one-way was the only tool that would penetrate and loosen the soil and kill the weeds. Light rains fell in July, wetting it to the depth of 1 foot, after which the lister was used, and later the ridges were leveled. After the ridges had been leveled, light rains occurred. The best implement with which to work the land was the rod weeder, which few farmers possessed. Instead of being listed in late July, the land might have been worked with a field cultivator, and near seeding time with a rod weeder. To have worked this land several times with the one-way would have left the soil thoroughly pulverized and in a condition to blow.

Case 3.—This case is of rather frequent occurrence in some hard-land sections: A dry July in which only a stunted growth of weeds occurred; repeated rains in August or September, which made it impossible to get into the field; a heavy growth of redroot amaranth (*Amaranthus retroflexus*) that consumed much of the moisture before the heavy, hard land was dry enough to work; and finally, the land worked shallow with the one-way, turning under a blanket of weeds. Light rains occurred later, wetting the top few inches, enough for germination of wheat. The surface dried out, owing to a heavy blanket of weeds keeping the soil loose. Wheat roots did not penetrate through the blanket of weeds and died. Dust blew from the surface of the soil, which was held up loosely by weeds all winter. On heavy soils in sections where weeds are likely to make a heavy growth quickly, it is well to work the land immediately after harvest with some implement that kills the weeds and breaks up the surface. This makes it more receptive to rain, and puts the land in such condition that later it can be worked rapidly with implements such as the field cultivator and the rod weeder. If it is in a hard, packed condition so that heavy, slow work must be done, weeds may often get ahead of the operator and consume moisture that is usually essential for producing a paying yield of wheat.

Case 4.—There is a very heavy wheat stubble on hard land. Weeds very often germinate poorly in such stubble, nor is there much run-off. If it is burned in September, one-wayed, and planted to wheat, surface blowing and eventually more serious soil drifting are encouraged by the lack of straw as a protecting material. If it is one-wayed immediately after harvest, the one-way often should be followed by a heavily weighted packer. This presses the straw into the soil, where with moisture it will rot rather than remain as a blanket partially covered with loose soil. A loose cover favors drying of the surface and may result in later soil blowing. It is often impossible to force drill disks through it and obtain a stand of wheat. In case of numerous summer rains, a second one-waying will soon be necessary. This will further mix and incorporate the straw with the soil (fig. 13). If further cultivation is required it is best not to pulverize the soil further or to chop the straw up any more with the one-way, but to use the field cultivator or the rod weeder, both of which bring clods and straw to the surface.

Case 5.—This is a case of sandy or sandy loam soil that is not too hard after harvest and listing is practicable. If there is likelihood of soil blowing if the lister ridges are leveled with the ridge buster, they may be leveled with the field cultivator or the rod weeder, leaving the centers between the furrows intact.

Case 6.—On the eastern edge of the Plains it is not an uncommon practice for farmers having sandy lands usually planted to wheat to plant them occasionally to sowed feed crops (sorghums planted with grain drill) and follow this with sweetclover. A stand of sweetclover in sowed feed-crop stubble is

shown in figure 14. Such stubble provides a clean seedbed and protects the young sweetclover plants. The sweetclover is pastured for 2 or 3 years. After this the land is returned to wheat.

FIGURE 13.—One-way used to kill weeds and volunteer wheat, followed by a subsurface packer. This prepares a firm seedbed resistant to soil blowing.

FIGURE 14.—Stubble of close-drilled sorghum, providing an effective protection against soil blowing, even on sandy soils, and offering a clean seedbed in which sweetclover or grasses may be seeded and protected in their early growth.

Case 7.—A short, nearly weed-free stubble frequently occurs in the northern and western portion of the southern Plains. Planting wheat directly in such a stubble is preferable to working the soil shortly in advance of seeding. The standing stubble effectively prevents soil blowing and may be of value in

catching snow. This practice is adapted only to that portion of the area where wheat harvest is not early and the stubble is normally clean. Where vigorous weed growth takes place after harvest, the weeds remove available water and greatly reduce the chances of producing a wheat crop.

Case 8.—When fields have been stubbled in or very superficially disked for a number of years, the surface inch or two may become a mixture of dust and finely ground vegetable matter which blows easily. Certain weeds gain ascendancy, and yields decrease. The plow has become almost a thing of the past in many sections of the Plains. But nothing would be better for a soil in this condition than a thorough plowing to a depth of 6 or 7 inches. In place of the plow the lister may be used, though it is less efficient in bringing new soil up and burying the surface dust.

SEEDING WHEAT

In years past when there was not enough moisture in the soil to bring up a wheat crop, the seed was dusted in, in the hope that succeeding rains would be sufficient not only to bring it up but to mature a paying crop. Recent studies have indicated that unless the soil contains enough water to germinate wheat and maintain its fall growth there is little hope of maturing a paying yield. Nevertheless large acreages of wheat are planted nearly every year under such conditions. A considerable portion of this acreage is planted on late-prepared land as an adventure or a gamble by a certain class of people, often not residents on the land, who hope each year that this will be the bumper year that they have been expecting. Knowledge that chances of failure are exceedingly high when wheat is planted in soil that is dry at seeding time, and that the chances of failure are still more than one in three if the soil is not wet to a depth of more than 1 foot, should reduce the acreage of this speculative type of wheat growing. Further realization that there is less than one chance in five of obtaining a yield of as much as 20 bushels per acre on land wet to a depth of less than 1 foot at seeding time should convince such growers that planting under adverse conditions is a losing gamble. Less wheat planting under poor conditions will simplify the control of soil blowing.

Sometimes when there has been no rain during the latter half of the summer fallow soil may be dried out to a depth of 3 to 5 inches, although below that it may be wet to a depth of 2 or 3 feet. Dusting-in is hazardous even in such a case, as the seed will be lost if no rain comes. If rains come, they may pack the soil until the emergence of wheat is difficult and blowing starts easily over the smooth surface. Under the conditions mentioned a stand may sometimes be obtained by use of the furrow drill, but such instances are rather rare.

A great many inquiries have been received by the Department of Agriculture and by experiment stations serving the Plains as to the relative merits of the furrow drills and the common drills for seeding wheat.

About 20 years ago furrow drills, usually with about a 14-inch spacing between rows, began to gain favor. Some were hoe-type drills, and others were of various disk types. Extensive experiments have been run with them at several experiment stations and on several types of soil. At most stations the average yields when furrow drills are used are about the same as when ordinary drills with 6- to 8-inch spacings are used. The furrow drills, after rather extensive trial, proved unpopular with farmers in some sections. The objec-

tions were made that when heavy rains came after the grain was planted, the furrows formed channels from which soil and seed were washed, or that the furrows filled in and buried the seed so deeply the plants did not come up. Sometimes the action of wind filled in the furrows so deeply as to smother the wheat or bury the seed so deeply that the plants could not come through. Often when the ridges held they were at least decidedly objectionable when harvesting with the combine.

The furrow drills with their wide-spaced rows have found greatest favor in those sections where there is a high percentage of loss from winter-killing and soil blowing. The ridges provide some direct protection against soil blowing and sometimes hold a protective cover of snow. Because the ridges may be mellowed into a condition susceptible to blowing, the use of the furrow drill is most advantageous when it is accompanied by other cultural practices that leave a protective cover of stubble or trash on the surface. In most of the area to which this bulletin is specially applicable, the choice of the type of drill to use under average conditions is largely a matter of personal preference.

CULTIVATION AFTER SEEDING

After wheat has been seeded there is not a great deal of danger of blowing until December, unless the soil is finely pulverized and free of crop residues. After that time the soil is often covered with a crop on well-prepared land on the eastern edge of the Plains. On the western edge of the Wheat Belt, especially in sandy soils, there often is not enough growth of crop to cover the soil. Often even though land is in a condition to blow, it does not move to any damaging extent until February or March because there is little wind.

Land that is in a condition to blow will generally do so some time during the late winter or early spring. Protective cultivation that holds the soil in place during this critical period frequently decides whether or not a crop will be produced. Fear that some wheat will be destroyed has caused many farmers to delay or avoid preventive cultivation, but it is becoming better and better understood that cultivation of wheatland reduces the yield of wheat little or none. The plants remaining can make effective use of all available moisture. The protective cultivation that should be given varies with the character and surface condition of the soil.

It is generally recommended that preventive cultivation be done at right angles to the most severe winds. This is desirable but difficult, as the direction of high winds varies considerably. No matter which direction the furrows are run, there is always the possibility that a high wind may blow parallel to them, at least for a short period. For most areas in the southern Plains, running the cultivated strips east and west is preferred, although there are occasional severe winds from due west. The direction of the strips for the different portions of the Plains should be based on past experience of the direction from which damaging winds are most likely to blow. It is safer when more than one cultivation is given to checkerboard the land, thus guarding against soil movement from any direction.

The cultivation that should be practiced under some fairly typical conditions may be illustrated by means of specific cases.

Case 1.—On heavy land when blowing starts because of rain having created a smooth surface, the best remedy often is to run a lister furrow every rod or two (fig. 15). The raised edges of the furrow stop the movement of soil particles along the surface. These particles collect in the furrows, where they remain inactive and do not contribute to further soil movement. The raised edges of the furrows also help to raise the force of the wind away from the surface. In case further work is necessary, other furrows are run between the original ones, or lighter furrows at an angle to the first ones may be made with a cultivator.

FIGURE 15.—Strip listing (listing one or two furrows every 2 to 4 rods). This provides protection against soil blowing for a short time or where only moderate protection is needed. When the furrows are filled their usefulness is ended, but the operation can be repeated.

Case 2.—Sometimes on hard land the whole surface is dusty for an inch or two, because of the disintegrating effects of frost, snows, or light rains, although there is moisture or a cloddy condition underneath. In such a case it is better to run lighter furrows at shorter distances apart. For this purpose the lister cultivator with only the cultivator shovels (not the disks) is good, as is also the field cultivator or the ordinary surface row cultivator. Ridges in this case are often thrown up 4 to 6 feet apart, and later other ridges at right angles to these may be run, making a checkerboard effect and protecting the surface of the soil whatever the direction of the wind. Sometimes the furrow drill is used for this purpose, the hoe type being better than the disk type. Most of the hoes or disks are removed for such use (fig. 16).

Case 3.—Where the land is sandy, the more superficial cultivation rather than the lister furrows is always advised during the earlier part of the season. The checkerboarding with cultivators, thus guarding against wind from any direction, is a most excellent though somewhat severe practice. If listing is done on sandy land, the ridges thrown up by the lister do not last much longer than the smaller ridges thrown up by the cultivator, and since they cannot be used in equal numbers without destroying the crop, they are less efficient.

Case 4.—Sometimes there is a problem of 3 or 4 inches of loose, ashy soil. In such a case, ridges thrown up by a lister may often consist largely of loose

dust and be ineffectual. Under these conditions cultivators may sometimes be run over the field when the surface is wet only an inch or two from light rains or snows, and ribbons of moist earth be thrown up, which will harden into clods.

Case 5.—Very often a high wind prevails after a heavy rain that packs and smooths the surface when wheat does not have growth enough to make a cover. Under such a condition fine particles of soil may start gilding over the surface. Often a crop that is just emerging will be severely damaged or killed before the field is dry enough for implements to be used. This is particularly true in soils having considerable sharp sand in their make-up. Under such circumstances a six-horse team driven across the field may roughen and puddle the soil so that it will not blow for a long time. A drove of cattle would serve the same purpose if the animals could be driven loosely scattered rather than following one another.

FIGURE 16.—Disk furrow drill with all but two disks removed being used to protect a light growth of wheat.

In some cases a drill or a spring-tooth harrow may be run over such a field so lightly that, while creating clods, it will destroy practically none of the crop. When a furrow drill is used some of the disks are often removed. If the crop was planted with a furrow drill and the ridges are still standing up well, the rake run crosswise would in some cases be very effectual.

Case 6.—Soil blown from a roadway may sometimes cause blowing to start along the edge of a wheatfield. Soil blowing so started sometimes destroys whole fields. Lister furrows may be run parallel to a road to catch soil particles blown from it. In case the soil is too hard, the lister bottom may be removed and a chisellike blade 3 to 5 inches wide substituted. This will often throw up large clods, which will resist all abrasion from soil from the roadway and effectually protect the wheat. In some cases road scarifiers have been used for this purpose.

Case 7.—Heavy driving rains occur which pack tight soils very hard. If blowing does not start until after the surface of the soil is dry enough to work, or until it is baked hard, a chisel on a lister shank is sometimes the most effective tool for roughening the surface. The shape, width, or curve of such a chisel often needs special adaptation to the peculiar soil condition.

Case 8.—A great deal of hard-land soil was deeply one-wayed for wheat in the fall of 1936. It was so dry that a dusty cover 3 to 5 inches deep was created. Many clods an inch or less in diameter were in many cases scattered through this dust. There was about enough moisture to germinate wheat, but the loose

dust dried out and the wheat died. From these fields came some of the worst dust storms. Gradually as the surface dust moved off, the coarser particles were exposed and dust storms started less easily. In a few cases spring-tooth harrows and field cultivators were used to lift clods to the surface before dust storms developed.

Case 9.—When a very superficial disking has been given the soil previous to planting, and it is hard and packed except for the first inch or two, clods may sometimes be brought to the surface by the use of the chisel on the lister shank.

Case 10.—Many fields have sandy knolls and hillocks scattered over them. At the crests of these, growth is often very poor, and blowing starts from them and spreads to other parts of the fields. Manure or other farm refuse scattered over them will often hold whole fields. If there is a lack of any material to scatter upon them, light cultivation may be resorted to.

ABANDONMENT OF WINTER WHEAT

Sometimes in late winter it is obvious that, because of drought, soil blowing, or failure to make a stand, the wheat crop cannot be expected to make a paying yield. In such a case the land should be prevented from blowing by one of the methods previously described. If there is sufficient moisture to allow listing, this may be done, as it will almost surely stop any soil movement for the remainder of the season. If the land is to be planted again to wheat, it should be cultivated enough to prevent the growth of weeds until wheat-planting time. The moisture collected during the spring months and before wheat is normally harvested is usually of far more importance than is generally recognized in aiding the following wheat crop to produce a paying yield.

In case a row crop is to be planted, the listing is the first step in the preparation of the land for this crop.

FALLOW FOR WINTER WHEAT

Where winter wheat is being raised almost exclusively, the method of fallow usually practiced is to allow the land to lie in stubble after harvest and through the winter. Tillage should begin in the spring as soon as weeds start vigorously, and the cultivation to control weed growth should continue until nearly wheat-seeding time, the same precautions being observed to keep clods and trash on the surface as for continuously cropped wheat. In general, cultivation should be confined to the fewest possible operations necessary to control weed growth. A fallow cannot usually be safely maintained with a one-way exclusively through this long season, as it pulverizes the soil and makes it susceptible to blowing.

Efforts are sometimes made to give fallow some of the protection of cropped land by planting milo or kafir on it in abnormally wide-spaced rows, up to 16 feet apart. Such rows of crop use water that could be conserved for the use of wheat. Such use may, however, be partially compensated by earlier and cleaner cultivation than might be given fallow. There is a return in the crop produced by the rows planted for protection, but this may not be sufficient to offset the reduction that may be expected in the yield of wheat.

Sometimes cultivation of wheat stubble is begun immediately after harvest with the intention of planting wheat in the fall; then moisture conditions do not warrant planting, and the land is carried as a fallow. Under such circumstances cultivation to prevent soil drift-

ing is usually a necessity. On heavy land it will usually be found advantageous to list some time late in the fall, with the expectation that ridges will hold until April or May, at which time the worst of the blowing is over and cultivation to destroy weeds should start. If the ridges become smooth or dusty from rains, snows, or wind, they can be roughened with a cultivator or a rake.

On sandy soil listing usually should not be done until the possibilities of holding the soil by more superficial cultivation are exhausted. If listing is done early in winter on sandy soil, the ridges often will dry out and start drifting, filling the furrows. When this happens, some clods may be pulled up from the base of the ridges or the ridges may be split. If loose soil occurs early, it is almost impossible to hold the field through the remainder of the blow season. With many sandy soils it is usually well to try to manage so that listing need not be resorted to until as late in March as possible.

The Soil Conservation Service has repeatedly drawn attention to the fact that during a series of droughty years when there have been successive wheat failures the crop residue is exhausted and it is difficult to keep the soil from blowing. In such a case it is sometimes better to put the field in sorghum than to risk fallowing it for wheat.

In many cases wheat has been sown directly following the sorghum. Soil where a sorghum crop has been grown usually contains little or no available moisture and there is little chance to obtain a paying yield. On the average there is little hope of producing a paying crop of wheat following sorghum anywhere in the southern Plains. Sorghum land might better be allowed to stand in stubble over winter and be fallowed for a wheat crop the following fall.

CULTIVATION FOR ROW CROPS

HANDLING SORGHUMS AND COTTON TO PREVENT SOIL BLOWING

On land that has grown a crop of sorghum the surface inch or two of soil is usually loose. Added to this, livestock are usually turned into fields after harvest and still further pulverize the soil. There is considerable complaint of sorghum land blowing during the fall and winter. It is usually hard and dry a few inches under the surface, and clods may be brought to the surface with a strong cultivator or a chisel on a lister shank. When moisture is present, hard land may be listed in the fall with the expectation that it will hold over winter.

Much sorghum is grown on sandy soil in the drier parts of the Plains. Listing such soil early in the blow season is usually not advisable, but a field may be crisscrossed with a surface cultivator (fig. 17) or some other implement adapted to the purpose, such as a stiff-shanked field cultivator with most of the shovels removed and narrow shovels substituted for duckfoot shovels (fig. 18). Examples of the work of this implement are shown in figure 19. Such cultivations may be repeated several times if necessary before the clods and moisture in the first 3 or 4 inches have been exhausted. In late February or in March listing may be resorted to. Any farmer with a few years' experience can determine whether it is wiser to use light cultivators or to list as soon as blowing becomes a menace.

Stalks of row crops left standing are often very effective in preventing soil movement. This is especially true as long as the leaves remain upon them. They are also often useful in holding a blanket

FIGURE 17.—Cultivating with an ordinary surface cultivator with all but one shovel removed from each gang. This procedure is very useful, especially on sandy soils. It does not disturb and dry out the soil so deeply as when a lister is used. When the ridges wear down, the cultivation may be repeated at right angles to the first operation.

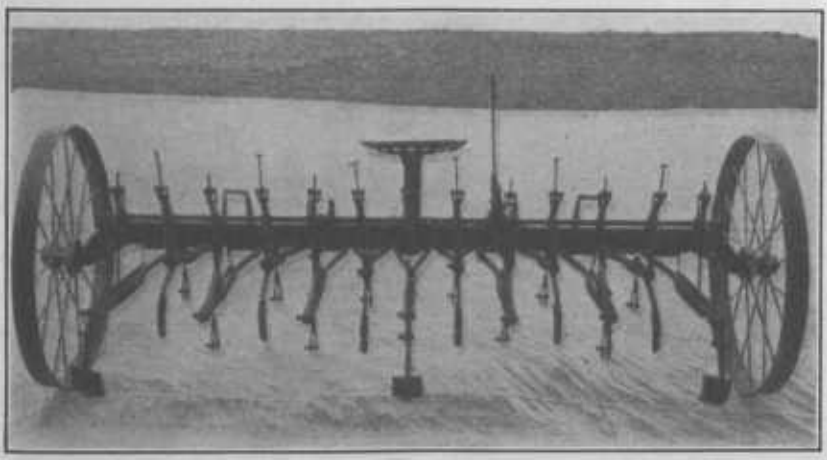

FIGURE 18.—Stiff-shanked field cultivator with most of the shovels removed. This implement is useful to check or prevent soil blowing on row-stubble fields, bare cultivated land, or land already seeded to wheat.

of snow on the surface. Along toward spring, however, they become nothing but so many weathered sticks that obstruct blowing but little. If heavy, they may then sometimes break over unevenly or catch weeds, creating unequal obstructions which may accumulate

hummocks of soil, from which blowing will start afresh. It is sometimes better to break them down rather than to leave them standing longer. This can be done with an iron rail or a heavy timber, or

FIGURE 19.—The stiff-shanked field cultivator with most of the shovels removed in use on sorghum stubble land to create a surface resistant to blowing: *A*, Cultivating at right angles to the rows of stubble; *B*, cultivating a terraced and contour-planted field.

still better with a stalk cutter. Lying flat, they are very effective, on some soils, in obstructing the heavy particles that would otherwise drift along the surface. Even cotton stalks, while slight in

bulk, are woody and are quite helpful in preventing soil drifting when they are flattened on the ground.

In sandy loam soils on the western edge of the Plains, fallow is in many cases a good insurance of a sorghum crop. However, a fallow for sorghums must lie bare during the winter previous to planting, and the risk of blowing is considerable. By following the precautions used in fallowing for wheat, of having the soil compact close to the surface rather than loose to some depth, it can usually be held if the field is not too large to be manageable.

The most difficult problem to deal with in some of the sandy sorghum- and cotton-growing areas in the drier parts of the Plains is the size of the cultivated areas. Often one field consisting of several hundred acres may lie adjacent to other fields of like size. If blowing develops on one field, others may be quickly involved. An example of how blown soil from one field may hamper control measures on a neighboring field is shown in figure 20. Without

FIGURE 20.—Soil blown from one field to another (upper right). Even lister cultivation cannot arrest soil blowing when it stirs only accumulated blown soil.

the accumulation of blown soil, listing would have protected the entire field. If fields were smaller and had areas of grassland between them, general blowing over a whole neighborhood would not develop so easily as at present. Each individual field could be handled as blowing developed on it. There would not be the menace of outside fields starting it.

In some cases buffer strips, several rods to several hundred feet in width, of grass, scrub oak, yucca, sumac, or other native shrubs have been left on the south and west sides of fields to prevent the neighbors' soil from drifting in. In some cases these buffer strips have built up to several feet in height, forming dikes that are effective barriers against indrifting soil.

In the absence of native grass or shrubs, the planting of strips of Sudan grass on areas harried by inblowing soil is sometimes advisable. The many fine stems of Sudan grass, whether it is sowed or is planted thickly in rows, seem to deter soil drifting more effectually than do the remains of other crops.

HANDLING BEANS AND COWPEAS TO PREVENT SOIL BLOWING

Beans and cowpeas have an ameliorating effect on the soil, which causes it to blow easily. On the field stations throughout the area the general practice has been adopted of planting two rows of either of these legumes in alternation with two rows of either Sudan grass or milo. The two rows of legumes are thrown together with a pea or bean harvester into a windrow (fig. 21) and later cocked. If

FIGURE 21.—Harvesting double rows of cowpeas planted between strips of Sudan grass.

one of these harvesters is not available, it may be found more practicable to grow six or eight rows of legumes so they may be harvested with a mower. In such a case an equal number of rows of Sudan grass or milo should be grown. The stalks of milo or high stubble of Sudan grass should be left on the ground. The soil where legumes have been grown may be mellow enough to drift in spite of preventive cultivation. That where sorghums have been grown will be more solid, and cultivation when required should effectively prevent soil movement. The clods thrown up will hold soil that may drift from the legume strips. In the higher altitudes corn and beans are alternated in the same way.

STRIP CROPPING

The advantages of growing crops like cowpeas and beans, which leave the surface of the soil in condition to blow after harvest, in alternate strips with sorghum or Sudan grass have already been discussed. The desirability of using grass or pasture to break up wide stretches of farm land is discussed elsewhere.

Success in controlling soil blowing in the northern United States and in the Prairie Provinces of Canada by alternating strips of grain with strips of summer fallow or corn has led to much speculation regarding the possibilities of a similar practice in the southern Plains.

The system employed in the northern Plains cannot be used without change in the southern Plains, as major differences in crops grown and in the number of insect pests present make modifications necessary. At present too little is known regarding strip cropping under southern conditions to serve as a basis for making broad recommendations. Until its adaptation to the different parts of the area has been determined, judgment of its value must be suspended. Throughout this area the Soil Conservation Service and other agencies are conducting widespread trials of strip cropping, which should serve to establish its possibilities and limitations.

Growing crops such as corn or sorghum in strips alternating with wheat favors injury by insect pests such as chinch bugs and grasshoppers, which migrate from one crop to the other.

While more information is needed on the most effective methods of employing strip cropping to prevent erosion, it is reasonable to believe that it merits serious consideration over the old method of exposing large areas to erosion, which has proved in many cases to be destructive of soil and a disastrous failure. Suitable combination of crops grown in proper sequence or in connection with a fallow system, designed to control the spread of insect pests, will have to be developed if crop production is to be a part of a permanent agriculture in the Great Plains.

Strip cropping alone or applied to an occasional field cannot be expected to give the most satisfactory results. When extensive areas are protected with strip cropping combined with rough tillage, contour or basin listing, and proper utilization of crop residue, the wind-driven soil or sand will have little opportunity to accumulate in destructive quantities. The soil movement will be checked before it gains headway.

The necessary amount of strip cropping can usually be planned without disturbing the balance or acreage of the regular crops that should be produced in any given area. With a more intelligent land-use program, retiring to grass the less productive crop areas, and a better adaptation of crops to soil, strip cropping in conjunction with the other erosion control measures will be more effective.

SHELTERBELTS

Not only are strips of native browse and grass often useful in checking soil movement, but so are rows of trees. Trees are sometimes very efficient in causing the piling up of sand and thus preventing it from scouring fields and damaging improvements. In sandy lands such rows of trees may sometimes pay for the investment, if planted for the particular purpose of keeping the neighbors' soil from drifting in. They may, however, be too difficult to establish, because of whipping by sand, or because of soil blowing or washing away from roots. In the hard lands trees do not grow so well and are more easily killed out by dust heaps piling up about them. It is hardly worth while to plant trees extensively in the drier, hard-land portions of the Plains.

At the Tucumcari, N. Mex., field station, three rows of Chinese elms were planted 1 rod apart, with the trees 6 feet apart in the rows. The trees stopped the sand from the neighboring field from blowing in by decreasing the force of the wind and causing the sand

to pile up for 50 feet to leeward of them. Some tree windbreaks have been killed by blowing sand, but the Chinese elms have survived. Other trees, such as jujubes and desertwillows, might be as resistant. There seems to be evidence that trees will withstand sand piled up aronnd them better than they will silt, as the moisture penetrates the sand more easily and they do not die from drought.

At the Dalhart, Tex., field station a picket fence was placed along the south and west sides of the farm at the beginning of the recent drought period. During the succeeding years soil from neighboring fields was stopped by it and formed a dike several feet high and several rods wide. This barrier has served effectively in preventing erosion which otherwise would have been caused by soil movement originating on adjacent land.

Such artificial barriers are unsightly but are justified when it is necessary to resort to extreme measnres to protect a farm from the inroads of soil from neighboring fields. A cheap and effective fence for this purpose can be constructed by stretching a single wire between widely spaced posts. The thistles caught by the wire will form an obstruction sufficient to arrest the drifting soil.

On building sites, even in the driest parts of the Plains, trees are of first importance. Here enough litter can usually be scattered to keep the soil from blowing away and exposing the roots. Comparatively few trees are needed; consequently they can be kept well cultivated, and at least a few of them can be watered. Through their protection, the area immediately around the buildings can be kept free from the worst ravages of the wind. Under such protection it is easier and pleasanter to work, and shrubbery and flowers can be grown, making the home pleasant and attractive. This is particularly true if the tree plantings can be supplemented by an adobe or rock wall, which is often possible, though these too often are relics of pioneer days rather than features of modern construction. They may not be extensive, but they offer a practical means of protecting ornamental and vegetable gardens. Behind them flowers and shrubbery can be started much more easily than in the open. In lieu of these, rows of corn, sunflowers, or castor-beans are often grown.

On the windward side of the windbreak native sod should be left if possible for a distance of 20 to 40 rods. Lacking this, Sudan grass can be planted for pasture. Traveling across such a cover, the wind will lose many of the heavier particles blown from the fields and will not be so destructive on vegetation about the buildings. At the far edge of the grass buffer a row of some very tough and hardy plant may be run to catch the brunt of the wind and precipitate the bulk of the soil particles. In the southern Plains this might consist of desertwillow or jujube. Neither of these put out leaves until very late, and consequently they are not greatly injured by the scouring winds of early spring. Chinese elms have withstood the winds despite the fact that they put leaves out early.

An upstanding rather than a low-spreading type of plant should be used, as the latter may be quickly buried. The row may not be long-lived, but it may be replaced. In cases where the scouring by sand is too severe to allow plants to live, their place may be taken by a picket fence, such as is commonly used to prevent soil and snow from drifting into roadways.

REGRASSING

On the eastern edge of the Plains some sandy lands have very little fertility, and annual crops are grown at a loss. In the western and drier part of the Plains the very sandy soils drift so that the raising of cultivated crops is impracticable. There is imperative need that these be returned to grass. Grass should also be used for the protection of steep slopes that erode badly during the infrequent but violent downpours of rain. Cover crops such as clovers and lespedezas, which are used for protection in more humid sections, are not adapted to the dry climate.

Very large fields, sometimes covering several thousand acres, are especially subject to blowing, and it is probable that some of these should be broken up and partly put back into grass.

The sandier portions and those with soil of little depth should be in grass. They produce little crop and are a menace to surrounding land; if in grass they would be a safeguard.

In establishing new stands of grass or improving old stands, moisture is an important factor, and anything that can be done to conserve water should result in more vegetation. The Soil Conservation Service is making extensive use of small, closely-spaced, contour furrows to prevent run-off and have obtained some excellent results in increasing vegetative growth on some of these thin areas.

Often in the sandy soils on the western edge of the Plains a hundred acres or more in a thousand is less sandy than the rest, has less slope, and is in general better farm land. If guarded on all sides by grass, there is little danger that it will blow if carefully managed. Some sections of the Plains, marginal for farming, will eventually, no doubt, revert to ranches, with farming as a minor but important supporting element. In fact, numerous neighborhoods once farmed have already reverted to the farm-ranch phase, and this is the most stable organization under their conditions.

Interspersing pastures with farm lands seems absurd in other sections of the Plains. Often nearly level, deep, fertile soil will extend in all directions as far as the eye can see. The average yield of wheat or sorghum has been a paying one. The price paid for the land is such that only a heavy loss on the investment is realized from every acre in grass. In these communities it is unlikely that extensive resort will be had to regrassing for the control of blowing. It may indeed be more practicable and profitable to make considerable use of sowed pastures such as Sudan grass, early planted wheat, and sweetclover, especially for dairy herds. Such crops are also effective in protecting the soil surface when not grazed too severely.

Putting land back to grass is a subject upon which a great deal of research is necessary. Seed of most of the native grasses is often light in yield and low in germination. It is possible that grasses may be introduced from other regions of the world which give a heavier yield of seed, a greater percentage of which is good. It is probable, however, that to obtain a stand of grass in the sandier lands of the drier portions of the Plains will be a slow and sometimes a difficult task.

Certain developments, however, give grounds for hope that regrassing may become practicable. In the southern and central Plains it has been found that a stand of grama grass may be rather easily ob-

tained on land that is not too sandy. Buffalo grass likewise will quickly make a cover on tight land when small pieces of sod are planted a yard apart. It is possible that higher-yielding grasses or other perennial soil-binding crops may be found for many portions of the Plains, if sufficient study is devoted to the subject.

In many fields that have been cultivated for a number of years there probably remains enough native grass to repossess the land if it is encouraged and properly protected. It has been suggested that such protection might be afforded by planting Sudan grass in rows, seeding sweetclover in the stubble, and then abandoning cultivation. Both the Sudan grass and the sweetclover may be utilized by moderate pasturing.

While it would not be feasible to put the Plains back to grass in their entirety, still in the drier and sandier portions of the country much regrassing is essential to control soil drifting and to make the best use of land. In these localities when one season of drought succeeds another to such an extent that annual crops often fail, the soil is left bare and there is nothing to prevent soil movement, except tillage and other mechanical devices. Such resources are expensive and uncertain. Hence the great value of a permanent crop such as grass to tie down part of the soil and to prevent the movement of the remainder from one field to another.

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